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A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture

In This Issue

Cover

George Gruell, research wildlife biologist at the Intermountain Station, has compiled an extensive photographic record showing land changes in the Bridger-Teton National Forest in western Wyoming. Early documents such as these can help in land management planning today. Read more about it on page 7.

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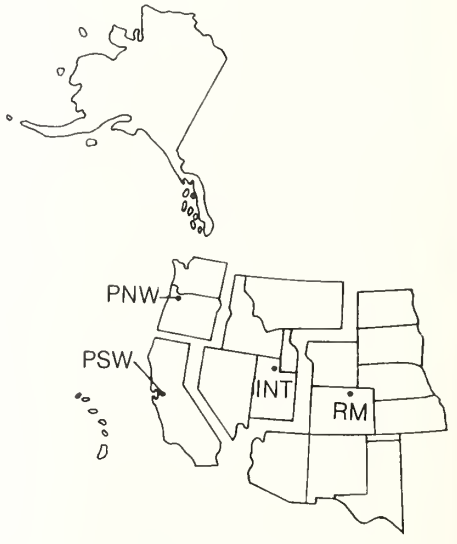
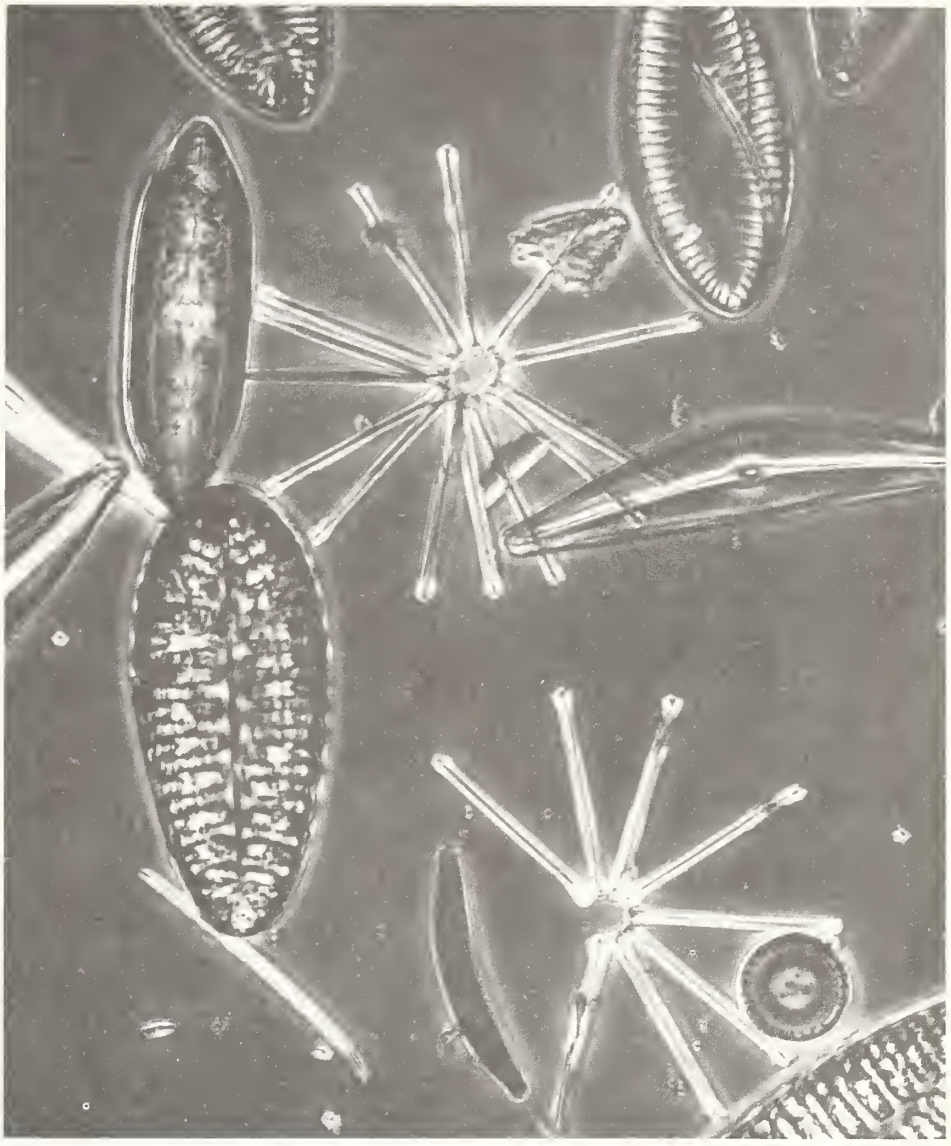


Using biologic organisms to test water quality

by Samuel T. Frear
Pacific Northwest Station



Diatoms and plant skeletons revealed under a microscope.

To Bill Fowler the question, in a nutshell, is: "Since the forest stream supports a biological community of plants and animals, why don't we use these organisms as indicators of the quality of water in streams?"

The Wenatchee Forestry Sciences Laboratory researcher does not propose to supplant the standard physical, chemical, and bacterial measures of water quality. He is convinced, however, that using the living organisms for water quality testing offers new opportunities for forest managers.

Fowler is working on a system of biological water sampling that would allow foresters and others—with limited additional sampling and a simple means of analysis—to evaluate water quality changes affecting the aquatic habitat and, hopefully, to understand why these changes are taking place. If nothing else, he hopes his research will encourage others to visit forest streams once in a while, turn over a few rocks, and see what is living there.

Fowler is the principal meteorologist for the Pacific Northwest Station's Wenatchee laboratory. He has conducted a number of studies on the relationship of plant growth to the environment. His interest in water quality was strengthened by participation in research about effects of major forest fires that ravaged the Wenatchee National Forest in 1970. He became aware of biologic water quality research conducted in Europe and eastern United States, and wondered if he could apply these techniques to the mountain lakes and streams of Pacific Northwest forests.

In simplest terms, healthy forest streams have great diversity in microscopic and macroscopic plant and animal life and are not dominated by one or a few species to the exclusion of others. Healthy streams maintain a physiological balance in the population of biological residents.

That these organisms are "residents" is the clue to the value of biological testing. Even after a pollutant has passed downstream, for example, and is no longer discernible by chemical or physical analysis, these biological residents can often provide evidence of what happened. The biological measure of a stream's condition is indicated by changes in species, number of species, number of individuals in each species, and the composition of the community.

Complex stream systems

From their knowledge of terrestrial systems, researchers expect that stream organisms vary greatly in sensitivity to various types of pollution. As pollution worsens, more and more species are eliminated until only the hardiest remain. These tolerant survivors may increase in numbers because of the lack of competition. With the aquatic plants, unattractive, odiferous, and sometimes noxious blooms can occur.

There are some problems in using biological data to indicate stream quality:

1. The collection of data can be time-consuming and expensive.
2. There is a need to simplify data so that people with little biological expertise can appreciate its uses.
3. Automatic ways to identify microscopic plants have been developed, but simple application of standards such as with physical or chemical measures are unlikely.

The problem of finding a simple and responsive system for use by forest managers is both "fascinating and frustrating," Fowler says. For one thing, it depends on what part of the biological system you use for the monitors.

The freshwater system is huge. The size of organisms ranges from virus particles to fishes, nearly as large a size range as marine or land species, with tens of thousands of species likely to be encountered. There still are discoveries being made. Within one diatom (plant) genus alone, 136 new taxa were recently recorded.

Fowler finds this work fascinating, not only because it offers an insight into the health of streams and lakes, but also because of the beauty and variety of the microscopic forms he observes. "These plants and animals rival their terrestrial counterparts," he said. "Each drop of water can be a mystery." That same drop of water also represents the "frustration" in the work. Often what you want to see is just below the ability of the eye to resolve and the number of species in even a small sample can be enormous. At two stages of magnification a translucent dot of lake water about the size of a pinhead on a microscope slide reveals an ornate collection of silicified skeletons of a plant group called diatoms. Some of the smaller diatoms, equally as ornate, would fit 10 or more within one of the larger models.

The overriding concern is to understand the responses of this very complex and prolific diatom community to the environmental factors in the stream. To reach this understanding, more biological samplings of streams and lakes are necessary. A background, reference data bank is needed to compare changes, since no standard values are available. Fowler believes this may be a timely endeavor as the long distance effects of atmospheric pollution, spread as acid rain, have created major changes in many remote lakes in Europe and the eastern United States. There is speculation that the highland lakes of the West are at the threshhold of pollution from atmospheric causes.

Plants and animals are sensitive

Of the many choices for indicator organisms, the benthic macroinvertebrates have most often been used as biological water quality indicators. One advantage is that they are relatively fixed in position in the stream. Thus they can show the desired integrated response to changing environmental conditions.

A chicken barbecue basket filled with rocks serves as a substrate sampler to collect both plant and animal growth for microscopic inspection.

Meteorologist Bill Fowler lifts a sampling net from a forest stream.

They are known to be sensitive to a variety of physical and chemical water quality conditions, can be identified with low power magnification, and in most cases occur in adequate numbers. Sampling can be a problem, however. Some species are more elusive than others and seasonal distributions are not similar among all groups. A Surber sampler, isolating for examination a square foot of stream bottom, or a simple drift net are frequently used for this sampling. Animals disturbed from the substrate are collected in the trailing net. Fowler also employs an artificial substrate sampler for both plant and animal sampling. The sampler is a chicken barbecue basket filled with rocks and left in the stream to allow plants and animals to colonize. The rocks are later scrubbed into a basin, producing specimens for analysis.

Fowler has so far concentrated his work on the aquatic plants, particularly those found attached to various surfaces, such as stones and plants, in the stream. This community, called the periphyton, also displays the desired integrated response. Some limitations for research of the organisms are that they are microscopic in size, keys may not be as easily available, and their distribution varies with substrate and season.

Fowler likes the aquatic plants, however, because they, along with organic detritus from land surfaces, provide the "fuel" for the system. A number of independent measurements of biomass production can be made reflecting how the system is faring.

Artificial substrate samplers are useful gathering specimens. Fowler, for example, employs a diatometer, a substrate arrangement using glass microscope slides to effectively sample the diatom community. These slides are left for weeks in the stream to allow diatoms to collect.

Sequential comparison index

Back in his laboratory, Fowler places samples (scrapings from diatometer slides or from the rock baskets) on a slide and notes the number of species found, the number of individual specimens of each species, and the order in which they occur. This may sound complicated but, as he explained, the critical element is only that the operator be able to distinguish whether this individual is the same species as the last one observed, not its taxonomic relationship. From the number of "runs" and the total of species in the sample, a simple but powerful population statistic can be determined, the Sequential Comparison Index (S.C.I.). Over a period of time, SCI's from these samples give a measure of the changing health of the stream.

In his research to investigate the practicability of using biological organisms to evaluate water quality, Fowler has sampled a number of streams and lakes. Comparing his sample from Lake Kachees to a model distribution expected of a healthy system and one impacted by toxic pollution shows how the distribution changes as pollutants limit sensitive species development.

Looking for an extreme example of poor stream health, Fowler also took samples at seven stations along the Coeur d'Alene River in Idaho, above and below mining sites that have had a recognized long term deleterious effect on aquatic life. Results from simple indicators from six sites from the headwater to Smelterville and one on the lower river below the confluence with the North Fork using number of diatom species, the S.C.I., and number of macroinvertebrates genera showed that despite significant efforts to improve the stream condition, there still is a troubled water system in the lower reaches.

Watershed studies

As part of the calibration process for experimental watersheds in the Hansel and Allen Creek drainages near Wenatchee, Fowler has also collected diatometer slides and rock basket samples exposed for 2- and 4-week intervals for several years of record. These will form the basis for comparisons to be made on the six gaged watersheds as aquatic habitat responds to the logging underway this fall and winter (1980-81). A complete background of physical and chemical records is available for these streams as well as corroborating atmospheric measurements.

Fowler admits there are many things to sort out on the way to developing a usable biologic water sampling system for land managers. But once a workable system has been developed, Fowler believes many applications are possible. Rather than merely relying on irregular physical and chemical sampling of a stream, a biological monitoring system can help identify large and small changes in the water environment, especially over time. Thus the land manager could know the effects, if any, on the aquatic resource of chemicals used for fertilization or brush control, of logging, site exposure, debris and sediment, leached or discarded chemicals, thermal influences, sewage effluent, and many others.

If you would like additional information about the research described here, contact William B. Fowler, Forestry Sciences Laboratory, 1133 N. Western Avenue, Wenatchee, Washington 98801. Phone (509) 662-4315 or FTS 390-0315.

Searching for ways to utilize beetle-killed pine

by Matthew McKinney
Rocky Mountain Station

Much of Colorado's Front Range is forested with Engelmann spruce, Douglas fir, lodgepole pine and ponderosa pine. Infestations of the mountain pine beetle (Dendroctonus ponderosae) are common and recurring, particularly in overcrowded ponderosa pine stands where trees are of low vigor and low resistance. During the 1970's, the mountain pine beetle was responsible for annual timber losses ranging from 5.5 to 27.3 million cubic feet. This expanding acreage of dead timber increased the chances of wildfire, while the aesthetics and property values of the forest land decreased.

Scientists at the Rocky Mountain Station believe that increased timber harvesting is a desirable means of forest management along the Front Range. Harvesting would help reduce the long-term threat of mountain pine beetle and other forest insects and diseases.

Harold Worth, leader of the Markets and Uses of Forest Resources project at the station, says, "Thinning is often required to create healthy and vigorous growing conditions in these overcrowded stands. When this is the appropriate silvicultural treatment, harvesting and utilizing the unwanted trees is not only the most productive solution, but the most economical one as well. Utilizing harvested trees for salable products helps finance treatments that improve the general forest quality and enhance specific multiple-use benefits, such as aesthetic quality and better wildlife habitat, in addition to supplying forest products to local and national markets."

Research

Research on mountain pine beetle infestations and potential uses of the wood is consolidated in three publications, available from the Rocky Mountain Station: *Processing Potential for Insect-Infected Front Range Forests,* Resource Bulletin RM-1; *Suitability of Beetle-Killed Pine in Colorado's Front Range for Wood and Fiber Products,* Resource Bulletin RM-2; and *Mountain Pine Beetle, Timber Management, and Timber Industry in Colorado's Front Range,*

Surveys indicate the potential annual harvest of timber along the Front Range exceeds the present processing capacity.

Resource Bulletin RM-3. These bulletins are the first in a new series of publications by the Rocky Mountain Station devoted to economic studies of natural resources.

Forest products industry?

Surveys conducted by scientists at the Rocky Mountain Station and Colorado State University indicate the potential annual harvest of timber along the Front Range exceeds the present processing capacity. In most cases, beetle-killed timber is suitable for the same products as live timber. In fact, special products like blue-stained paneling and beams made from beetle-killed ponderosa pine are in higher demand than similar products made from live trees.

However, a number of factors inhibit expansion of the forest products industry along the Front Range. Uncertainty of timber supply is a major one. Land use objectives of Front Range forest owners, both public and private, have changed rapidly in the past decade. The result is that some forests previously open to harvesting are now reserved for other uses, while other lands are in a "hold" status awaiting comprehensive land use decisions. Without reasonable assurance of an adequate and consistent timber supply, forest industries may not be able to justify required investments for new processing facilities.

Another inhibiting factor is the generally low value of the products made from Front Range timber. Upgrading these values would make it economically feasible to harvest more of the timber that should be removed to improve stand conditions. Timber killed or threatened by attacks of insect and diseases falls into this category.

In most cases, beetle-killed timber is suitable for the same products as live timber.

Utilization potential of beetle-killed wood varies with the length of time the trees have been dead before being harvested. Five years appears to be the maximum length of time dead trees remain utilizable for wood products. The suitability of beetle-killed ponderosa pine for wood products also depends on several wood properties such as mechanical strength and visual appearance. Along with these technical characteristics, harvesting, transportation, and processing costs are also critical.

Products currently produced

Major wood products now produced from ponderosa pine by Front Range industries include framing lumber, paneling, pallets, fencing, round timbers, houselogs, and firewood. A recent lumber recovery study reveals that lumber yield potential from standing dead trees (beetle-killed) approaches that for live trees. However, a higher percentage of low-grade products is generally obtained from beetle-killed wood.

Forest industries need assurance of an adequate and consistent timber supply to justify the required investments for new processing facilities.

Potential products

Worth says preliminary tests indicate that beetle-killed ponderosa pine is suitable for composite panel products, such as particleboard. These products have a slightly blue color, but are similar in other respects to particleboard made from live timber.

While studies suggest there is enough mill and forest residues along the Front Range to supply one or more particleboard plants of economic size, the critical factor in particleboard production may be the availability of sufficient raw material at an acceptable cost.

Other potential uses for beetle-killed trees include pulp and paper products. The feasibility of producing these products depends on moisture content, blue-stain fungi and amount of decay in the wood. In addition, the high capital cost of a mill, large water requirements and pollution hazards may discourage chemical pulping plants along the Front Range.

Still another potential use is for laminated wood products. A major advantage of laminated wood is its potential for upgrading product performance and values. By selectively placing laminae of the greatest strength where the highest stresses occur, wood product characteristics are modified. Studies show beetle-killed timber could be used if full strength material is placed in critical parts of the laminated members.

Multi-product most promising

Lack of processing centers and lack of a demand for wood products made from Front Range timber inhibits harvesting and expansion of the forest products industry. Disregarding additional management and marketing costs, the most promising type of expansion appears to be a multi-product operation that could convert each size and species of timber into the highest value end-products. In a recent study, it was found that at current prices, the potential products with the highest end-product values include, in decreasing order, blue-stain paneling, timbers, fence posts, utility poles, beams and finished boards.

If you would like more information on the utilization of beetle-killed pine along Colorado's Front Range, write the Rocky Mountain Station and request copies of the new Resource Bulletins mentioned at the beginning of this article.

Bridger-Teton's fire and habitat history: A photographic study

by Louise Kingsbury
Intermountain Station

"Some people see the photos and say, 'Hey, it looks a lot better today with the tall conifers.' The conifers might be esthetic, but they have shaded out other species—forbs and shrubs—that are important for wildlife habitat. The result is a reduction in wildlife use."

George Gruell maintains that this situation resulted from marked reduction of wildfire for many decades. And history, as revealed in Gruell's vast and unusual collection of then-and-now photographs, seems to support his contention.

During 10 years of nontraditional science research, Gruell, research wildlife biologist at the Intermountain Station's Northern Forest Fire Laboratory in Missoula, Mont., compiled an extensive photographic record of the changes of the land in the Bridger-Teton National Forest. He mostly narrowed his study to the Teton Division, or Jackson Hole area, of this western Wyoming forest.

Gruell complemented his historical collection with the "now" photographs he took himself, then selected 170 photos—85 pairs—spanning 103 years to appear in a research paper. The photos detail the changes, or lack of changes, in the contours and vegetation of this area's benches, ridges, springs, seeps, meadows, drainages, gullies, valleys, mountain slopes, and canyon bottoms.

Not ordinary

The recently published research departs from the ordinary. Natural resources research usually follows a traditional process that covers a relatively short period: defining the problem, creating study conditions, and quantifying the results.

But historians and long-range natural resource enthusiasts have to depend upon records kept by diligent and perhaps long-forgotten explorers, painters, and photographers.

"There is often a misunderstanding of landscape changes," says Gruell. "Early documents and observational records in places overlooked by the average researcher can help clarify what has happened to the landscape and help us in land management planning today."

"Even the descriptions by some of the early fur trappers of the mid- to late 1800's are helpful and important," says Gruell.

In the late 1960's, concern about the landscape and vegetation in western Wyoming led environmentalists and public and private land managers to speculate about the effects of human interference on wildlife habitat. To go beyond speculation and find out what those effects actually were, Gruell began gathering his historical records and photographs.

Pass Creek. Lateral movement of this stream channel takes great quantities of material from streambanks and sets the stream on a new course. Note establishment of lodgepole pine on flood plain at right (top photo - 1893) (bottom photo - 1968)

Overlooking Turpin Meadow. Famous pioneer photographer W. H. Jackson took the 1878 photo while with the historic Hayden Survey party. Ninety years later, conifers have matured and, in the distance, a new stand occupies openings created by a fire. (top photo - 1878) (bottom photo - 1968)

Photos from an attic

From 1968 to 1977, Gruell searched in corners largely unavailable to the scientific community, gleaning photos from libraries, historical archives, and obscure government files. He found photos thought lost during a World War II move, and even obtained some by a photographer whose daughter found the old prints in an attic trunk.

The result of the decade of research is an innovative two-volume set of photographs and editorial evaluation: *Fire's Influence on Wildlife Habitat on the Bridger-Teton National Forest, Wyoming.*

"This presentation is an invitation to biologists, geologists, botanists, archaeologists, and others to 'read' these landscapes and learn from the past," says Gruell. "It is also intended for use by nonprofessionals interested in the landscape."

So popular is the publication, even without much publicity, that it is now in its second printing through the Intermountain Station.

The 85 historical photos in the 200-page volume I cover 1872 to 1942. The 85 more recent photos were taken by Gruell in the late 1960's and early 1970's. This then-and-now approach compares the landscapes as shown in photos taken many decades apart, with explanation of any watershed or vegetation changes.

A shorter, 35-page volume II is intended for land managers, resource specialists, and the academic community. Here, Gruell details the changes, causes, and management implications suggested by the photos.

"The utility of such a presentation is that you can see what the land was like prior to land use planning and endangered species lists," says Gruell. "The use of so many pictures on a variety of sites gives us a more objective evaluation than when comparing just a few photos. The same story is seen across the landscape."

Role of fire

That story centers on the role of fire, which was the primary driving force influencing vegetative development. However, other information included is pertinent to esthetics, fisheries, forestry, range, geology, soils, hydrology, and fire management.

"This study makes the case that there are many opportunities to rejuvenate vegetation with fire, especially in some of the sagebrush-aspen communities," says Gruell. "The problem is basically that the deterioration of herbs, seral shrubs, and aspen has not been good for livestock or many wildlife species."

The biologist points out that prior to human settlement of Jackson Hole, wildfires stimulated renewal of vegetative cover by creating a mosaic of variable-aged vegetation. Now, after years of minimal fire, conifers have often taken over hillsides, suppressing aspen and shrubs.

Gruell concludes: "Use of prescribed fire as outlined in the Forest Service Fire Management Policy would rejuvenate vegetation and aid in fuel reduction, although it would require a great amount of coordination. What do we do with livestock, for instance, while we burn off and rejuvenate a range?"

Other resource issues

Gruell's pictorial study not only provides an insight on wildlife habitat condition, but also about other natural resource issues in the Jackson Hole area.

Some people, for example, worried that erosion rates had increased with human settlement. However, on moderate slopes, the photos show that many gully patterns and depths appear nearly the same after 50 to 75 years. Runoffs from steep slopes at high elevations are heavy. But the photos of the late 1800's and early 1900's show evidence of equally heavy runoffs.

Belief that erosion has increased with the changing patterns of elk use is not supported by the photographic evidence. On the Big Game Ridge, elk had been accused of contributing to the deterioration of grazable vegetation and of the watershed. But again, the photos do not bear this out. In fact, snowbank sites on the Big Game Ridge now support more plants than 50 years ago.

The photos do support some contentions that humans have altered the natural processes. Roads and buildings have changed erosion patterns. Off-road vehicles and campers have disrupted plant growth. Settlement, the state elk feeding program, and wheeled vehicles and snow machines have interfered with elk use of forage.

Many resource managers as well as preservationists feel that the long-range look through Gruell's photographic study will be helpful in deciding which land management policies would be best for the Jackson Hole region.

"This research gives us a handle," says Gruell. "Where have we been? Where should we go? That's the usefulness of these publications."

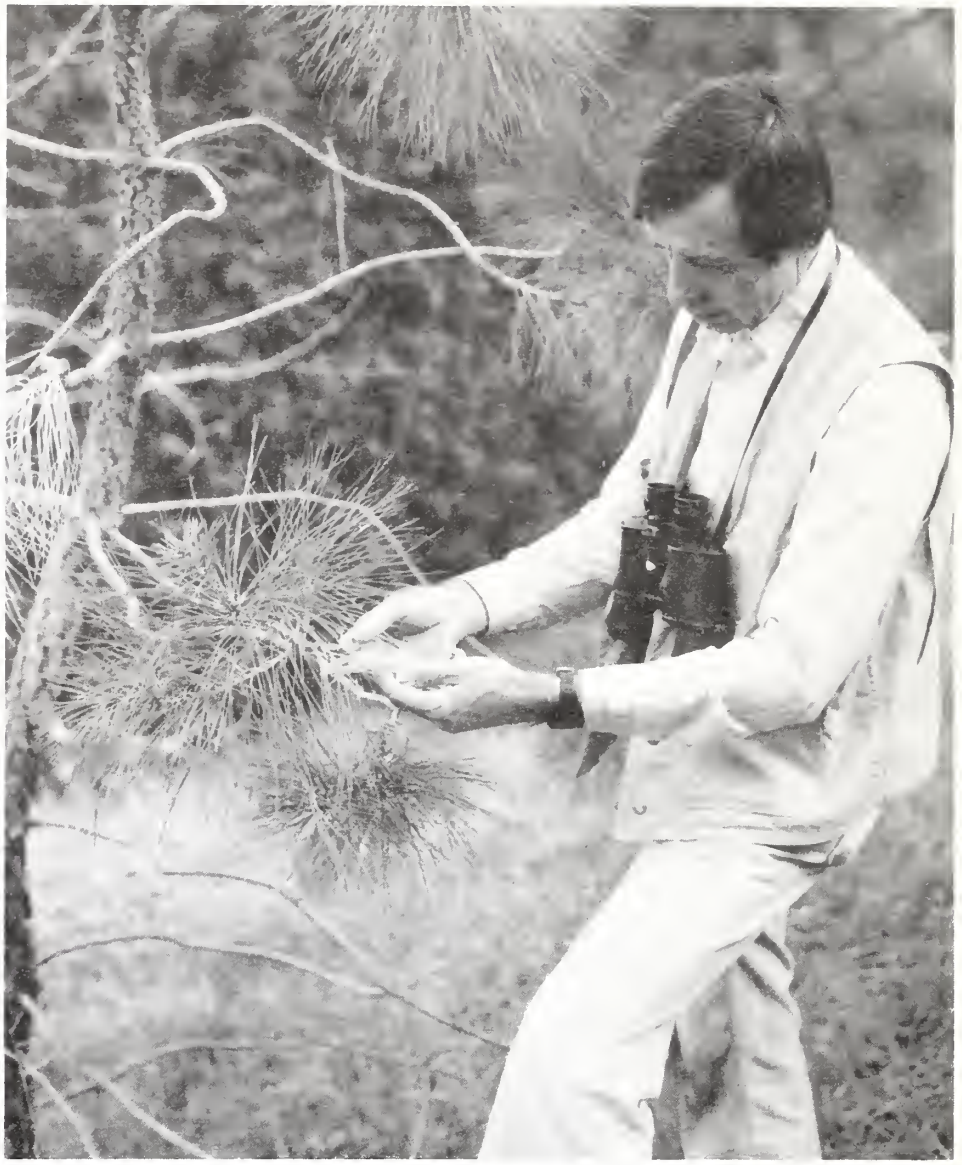
For a copy of one or both volumes, write to the Intermountain Station and request Research Paper INT-235-FR26 for volume I, and Research Paper INT-252-FR26 for volume II.

(The following have provided photos for use in this article: George Gruell, Almer Nelson, Claude Crisp, the University of Wyoming, the U.S. Geological Survey, the U.S. Fish and Wildlife Service, and the State Historical Society of Colorado.)

Goosewing Creek. The effects of lack of fire and of human use are evident here. The hillside, once swept by fire, shows even-aged aspen regeneration. Recent heavy use by campers and bedding livestock has altered the plant cover in the foreground. The elk trails have virtually disappeared because winter feeding has drawn elk away. (top photo - 1887) (bottom photo - 1969)

Ozone-damaged forests studied in California

by Marcia Wood
Pacific Southwest Station



Numbers of needle whorls, and the amount of ozone injury to each; needle length; and mortality of branches in the lower crown are all factors that Paul Miller, plant pathologist with the Pacific Southwest Station, uses to assess ozone injury to trees.

In a recent survey, the Riverside and San Bernardino area of southern California ranked fourth among the 10 U.S. cities with the worst air pollution. The dirty air in these California communities is a problem not only in developed areas, but also in the neighboring forests to the northeast, where ponderosa pine, Jeffrey pine, and other conifers in the San Bernardino mountains are suffering from pollution damage.

The pollutants that are injuring or killing these trees have been investigated by scientists from many disciplines. Among them is Paul R. Miller, a plant pathologist with the Pacific Southwest Station's Riverside Laboratory and a research associate with the Statewide Air Pollution Research Center, University of California at Riverside. Miller's analyses have ranged from a microscopic examination of the cellular damage that is caused by air pollutants, to a multidisciplinary investigation of the long-term changes that chronically polluted air can cause in a forest ecosystem.

Miller's primary focus is on the pollutant ozone—a gas that is the most damaging component of the Riverside and San Bernardino area's smoggy skies. Ozone, or O_3, is formed when ultraviolet rays in sunlight react chemically with hydrocarbons—mainly those from auto exhaust—and with nitrogen dioxide. Ozone and the other materials formed by the interaction with sunlight comprise what is known as photochemical oxidant air pollution, or smog.

Miller's research emphasis has been on developing guidelines for identifying the extent and severity of ozone damage to trees, and on providing information on how to manage forests in areas that will probably always be subjected to at least some degree of air pollution. Noticeably absent are studies of possible remedies for ozone-injured trees; Miller explains, "Nothing can be done about trees that are already severely injured by ozone, short of placing them in filtered enclosures."

Ozone in the mountains

Most of Miller's investigations of ozone damage have been conducted in the San Bernardino mountains, on the San Bernardino National Forest. During the summer, ozone levels in the mountains frequently exceed the health standards set by the Federal Government and the State of California. For example, the National Ambient Air Quality Standards, which are established by the Environmental Protection Agency, currently set 0.12 parts per million of ozone as the maximum allowable concentration that can occur during any given hour during the year. Compare this with the doses of 0.20 to 0.40 parts per million that Miller and other researchers say are not unusual for summer days in the San Bernardino mountains. Ozone in these forests can sometimes go as high as 0.58 to 0.60 parts per million.

Ecosystem analysis

The pollution problem in the San Bernardino mountains was the focus of a recent, interdisciplinary study on the effects of oxidants on a mixed-conifer forest ecosystem. With funding from the Environmental Protection Agency, Miller and other specialists from the University of California set about gathering data on dispersion of ozone in the study area; needle or leaf injury resulting from various doses of ozone; leaf fall and decay of litter; seed production; seedling establishment; and tree growth and mortality. Miller explains that one of the main objectives of the study was "to determine how the population dynamics of tree species, or forest succession, might be altered by different levels of ozone stress."

The daily peak concentrations of ozone, as recorded by ozone-monitoring instruments, are logged on a strip-chart recorder. These records are compared with ozone injury symptoms on sample trees.

The ecosystem level analysis has been the subject of wide interest among researchers and forest managers, and received international recognition at the June, 1980, symposium on effects of air pollutants on forest ecosystems. The symposium was held in Riverside, California, and was attended by more than 100 scientists from 15 countries. Members of the interdisciplinary study team explained various facets of their research, both in formal presentations and in a field trip to the nearby San Bernardino mountains study sites. (More information is in the "Proceedings of the Symposium on Effects of Air Pollutants on Mediterranean and Temperate Forest Ecosystems," which are available from the Pacific Southwest Station).

Miller's contributions to the study included analyzing the dispersion, or flow, of ozone through the study area, and determining the relation of tree injury to ozone dose.

Ozone dispersion

The purpose of the ozone dispersion study was "to determine how ozone concentrations differ at various distances from the urban source of the pollution." For this 5-year study, Miller maintained a combination of both permanent and temporary air monitoring stations at various sites in the San Bernardino mountains. The Skyforest station, which is about 9 miles northeast of the nearest urban source of pollution—the city of San Bernardino—was used as a reference point, to which data from all other mountain stations were compared. The results showed that average hourly concentrations of ozone at Skyforest during the summer months were about 0.08 parts per million. Downwind of Skyforest,

some 18 to 25 miles to the east, average hourly concentrations were only about 0.04 parts per million—the naturally occuring, or "background" level. Ponderosa and Jeffrey pine in the downwind area showed little or no ozone damage. At Skyforest, damage was moderate to severe. At a monitoring station about 13 miles west of Skyforest—and generally upwind—the average hourly concentration was about 0.10 parts per million, or 25 percent higher than at Skyforest. Miller says that the study provides "a unique example of the gradients of ozone dose and tree injury in a large, mountainous area downwind from an urban source of pollution."

Records compared

In a related analysis of ozone dispersion, Miller also compared the daytime concentrations of ozone at Skyforest, which is at an elevation of 5605 feet, with those of the city of San Bernardino, which is at 1180 feet elevation. Miller used year-around records from a 10-year-period for this analysis. Results showed that the average daylight concentration at the San Bernardino station was 0.027 parts per million; the average hourly dose at Skyforest was about 0.046 parts per million. "Higher concentrations of ozone during the night are frequently reported at mountain locations," Miller explains. "The higher daylight concentrations observed at Skyforest are derived mainly from higher early morning and late evening readings."

Injury response

In another part of the ecosystems study, Miller compared the response of various tree species to different doses of oxidant pollution. This information about the relative sensitivity of species common to the San Bernardino mountains was needed in order to predict how the species composition of the forest might change with continuing exposure to pollution. The investigation involved both analysis of seedlings in the greenhouse and evaluation of sapling-to-mature trees in the field. For the greenhouse and field tests, ozone injury symptoms were the same—chlorotic mottling, or yellowing, first of the older needles, then the younger ones; necrosis, or death, of needle tissue, starting at the needle tip; and abscission, or premature dropping of needles.

For the greenhouse study, Miller fumigated 2- to 3-year-old, containerized seedlings with 0.36 parts per million of ozone for 12 hours a day, for periods of up to 35 days. "We used this concentration because it is a frequent maximum for late afternoons in the summer in the San Bernardino mountains," Miller explains. The seedlings were placed in outdoor chambers, and were kept at temperatures and humidities that were as close as possible to those of the natural environment of each species. Ozone damage was estimated by examining new and year-old needles for signs of injury every 10 to 12 days during the fumigation period. In addition to native species, trees from other areas were used, to determine their potential as replacements for native species on sites that might require replanting.

The study showed that the Jeffrey pine-Coulter pine hybrid, which is widely used for restocking dry sites in southern California, and western white pine, were the most sensitive to ozone. Next were ponderosa pine and Jeffrey pine, which were almost equal in their sensitivity. In decreasing order of sensitivity, the other species tested were white fir, Coulter pine, red fir, the Monterey pine x knobcone pine hybrid, knobcone pine, incense cedar, big-cone Douglas-fir, sugar pine, and Rocky Mountain ponderosa pine.

Field analysis

The field analysis involved examining more than 2800 trees, over a 5-year-period, for symptoms of ozone damage. Stands in the San Bernardino mountains, dominated by ponderosa pine, sugar pine, and white fir; ponderosa pine and black oak; or Jeffrey pine and white fir, were used for this analysis. Injury was evaluated by analyzing several characteristics of the tree crown, including the length and condition of the needles, and the amount of branch mortality in the lower crown. Another characteristic used was the number of years' worth of needles (or annual whorls) that remained on the tree. The results showed that ponderosa pine and Jeffrey pine were the most sensitive to ozone. Miller suggests that these pines are reliable "indicator species" that can be used throughout the study area to gauge pollutant damage on the forest ecosystem as a whole. The study further showed that one of the crown characteristics used—the number of annual whorls remaining on individual branches in the lower crown—is accurate enough to serve alone as the indicator of crown damage.

A null balance porometer is used to measure the amount of water vapor that is being transpired through tree needles. These readings are used to estimate the rate at which trees absorb gases—including ozone—from the surrounding environment.

A healthy tree will retain at least 5 years' worth of needle whorls on each branch, and possibly as many as 8. A severely injured tree may retain only the current year's needles. Year-to-year comparisons indicated that, where tree damage was moderate to severe, the average number of needle whorls retained declined gradually; at plots with less damage, foliage retention increased gradually. The study also determined that the ozone level at which foliage injury begins to occur—during the May to September period—is at the average hourly concentration of 0.04 to 0.05 parts per million. According to Miller, this average is just above the background ozone level for the area. "At such low hourly averages, it is the frequency and the duration of daily peak concentrations that are most responsible for injury," he explains.

Ecosystem changes

The results from Miller's portion of the interdisciplinary study, and from the other researchers, suggest that moderate to severe ozone pollution can strongly influence forest productivity and composition. "We can expect that tree growth will be depressed, and that ozone-sensitive species will succumb more readily to attack by insects and root diseases," he says. "Further, regeneration of sensitive species may decline, because of reduced production of seed. The species composition of an ozone-damaged stand may shift from the typical ponderosa pine-dominated forest to an environment where the more ozone-tolerant species—white fir, incense cedar, and sugar pine—are prevalent. Unfortunately, the more ozone-tolerant species are sensitive to damage by wildfire. If fires break out frequently, it may be very difficult to keep certain areas forested. We may end up with brushfields at sites that were once highly-valued ponderosa pine forests."

The ecosystem study does not provide any answers for "saving" the severely damaged stands. What the research does provide, however, is concrete evidence of the damaging effects of ozone in a mixed-conifer forest ecosystem. This data can be added to the continually expanding base of scientific knowledge that is used by the Environmental Protection Agency for setting the National Ambient Air Quality Standard of allowable concentrations of ozone. It is the enforcement of this and other Air Quality Standards that offers hope for limiting the extent and the severity of air pollution damage to forests.

New Publications

To Order Publications

Single copies of publications referred to in this magazine are available without charge from the issuing station unless another source is indicated. When requesting a publication, give author, title and number.

Timber and the environment

Timber harvesting is the most significant management tool available to the forest manager, influencing almost all aspects of the forest ecosystem, including microclimate, hydrology, nutrient availability, esthetic quality, and insect and disease activity.

A pressing problem confronting forestry today is how to more efficiently harvest and use the timber resource without creating unacceptable environmental impacts on the forest. A September 1979 symposium in Missoula, Mont., explored this problem as it relates to the Rocky Mountain region.

The Intermountain Station has published the symposium proceedings: *Environmental Consequences of Timber Harvesting in Rocky Mountain Coniferous Forests.* The 25 papers cover basic environmental information, and biological and resource management implications.

Most of the symposium's research was conducted in forest ecosystems common to the lodgepole pine, larch, and Douglas-fir forests of Wyoming and Montana. Researchers evaluated an array of harvesting systems, silvicultural prescriptions, and utilization standards. They emphasized determining the biological consequences of different levels of use. Although the research was by necessity site-specific, the results have management implications for coniferous forests in general.

Also included are strengthened guidelines for prescribing harvesting practices to achieve land management objectives relating to esthetics, wildlife, hydrology, stand regeneration, and so forth.

The 526-page proceedings is available from the Intermountain Station by asking for General Technical Report INT-90-FR26.

Deer prefer overmature timber stands

Wildlife biologists working in southeast Alaska have found that Sitka black-tailed deer used silviculturally overmature stands of western hemlock and Sitka spruce more than adjacent areas clearcut 0 to 147 years previously. Findings from a study done in the fall of 1977 and spring of 1978 support those of similar studies by other scientists on Vancouver Island and do not support the view that clearcutting old-growth timber is always beneficial to deer.

The study was done on Admiralty and Chichagoff Islands by Olof Wallmo, formerly wildlife biologist (now retired) at the Pacific Northwest Station's Forestry Sciences Laboratory in Juneau, and John Schoen, research biologist with the Game Division, Alaska Department of Fish and Game, in Juneau. The findings were reported in the September 1980 issue of Forest Science.

Deer use was estimated by counting fecal pellets on a series of parallel transects on paired plots in even-aged stands of various ages and nearby uneven-aged, over-mature stands. Samples were taken in the fall of 1977 and again in spring 1978. The mean number of pellet groups per plot was larger in old-growth than young-growth stands for all paired plots during both fall and spring sampling. The ratio of use of old-growth stands to second-growth stands was 5.3 to 1 in summer and 7 to 1 in winter.

The authors believe that deer use is related to the amount of forage available and snow accumulation and distribution at various stages of forest development. There is no question that within two years after clearcutting there is a significant increase in browse production. But logging debris, and snow reduce forage availability for deer. Beyond age 30, the crowns become closed, the forest floor is in continual shade, and often devoid of understory vegetation. These stands remain even-aged through silvicultural maturity and provide little forage for as long as 300 years. When they reach seral maturity (and silvicultural overmaturity) stands are uneven-aged and have openings in the canopy which are associated with a variety of vegetation available as food for deer in winter. Since deer in much of southeast Alaska are confined by snow to lower elevations for several months each year, forested habitats that provide adequate browse are particularly important.

The biologists point out that little attention has been given to the quality of deer habitat provided by climax coniferous forests compared with younger forests. One reason may be that much of the uneven-aged, over-mature forests in North America were logged or burned before wildlife biologists began to record their productivity as deer habitat.

The study of deer use described in the current report is part of a broader cooperative effort by the Forest Service and the Alaska Department of Fish and Game to learn more about the food habits and energy and nutritional requirements of deer, the forest conditions that supply these, and the effects of management practices on these conditions.

Copies of *Response of deer to secondary forest succession in southeast Alaska,* by Olof C. Wallmo and John W. Schoen (Forest Science 26:448-462), are available from the Pacific Northwest Station.

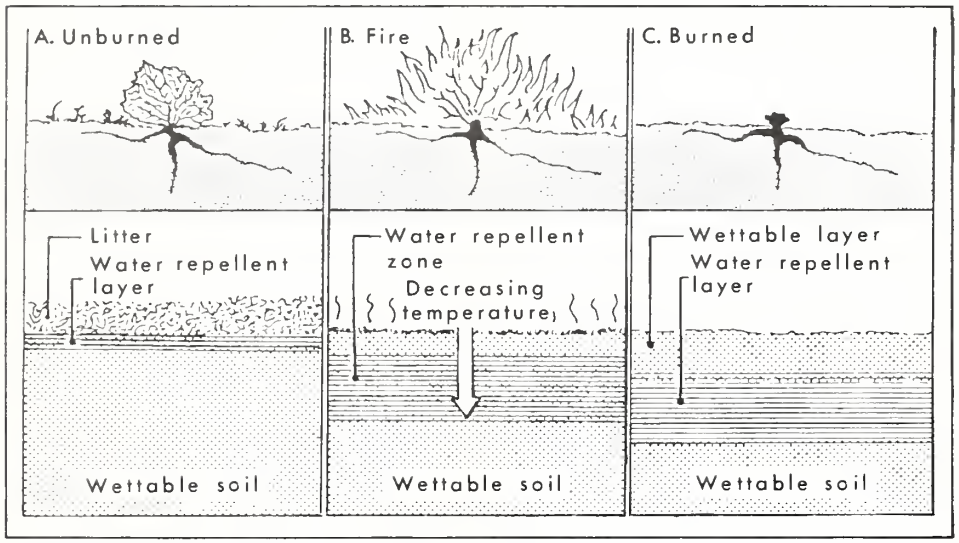
Figuring costs of recreational facilities

Decisions about the selection and design of public recreational developments can be facilitated by meaningful cost comparisons. Cost per user day of recreation provides a common basis for comparison. It relates costs of construction, operation, and maintenance of facilities to the level of use a development is expected to receive. A simplified approach to estimating cost per user-day is described in a new report from the Pacific Northwest Station.

Using campground construction as an example, the report provides worksheets and systematic, step-by-step instructions to separate and identify costs of capital investment and annual costs of operation and maintenance to get an average cost per user-day.

The method described can be used to compare the cost of providing comparable recreational services in different forests or regions as well as to compare the costs of different kinds of recreational service.

Copies of *Planners Guide for Estimating Cost Per User-Day of Proposed Recreational Facilities,* General Technical Report PNW-110, by Roger D. Fight are available from the Pacific Northwest Station.



Water-repellent substances accumulate in the litter layer and mineral soil of a brushfield (a); fire causes the substances to move down through the soil (b); a water-repellent layer is formed below the burned-over layer (c).

Water-repellent soils described

In the United States and in at least eight other countries, scientists have reported the phenomenon of soils that are water-repellent. These soils occur on forests, brushlands, grasslands, agricultural lands, and even on golf courses. The nature and formation of the soils is described in *Water-Repellent Soils: A State-of-the-Art*, General Technical Report PSW-46. The author, Leonard F. DeBano, is an authority on water-repellent soils of the Western U.S. He was formerly with the Pacific Southwest Station in southern California and is now with the Rocky Mountain Station in Tempe, Arizona.

In his review, DeBano describes the distribution of these soils and the substances that make them water-repellent. He also discusses the effects of water repellency on water movement, and the role that wildfire plays in the formation of water-repellent layers. He explains the land management problems water repellency poses, and talks about areas that need additional research.

DeBano may surprise some readers with his observations on advantages of water repellency. He says that in some areas—depending upon the soil type involved—repellency can conserve soil water, reduce nutrient loss, or improve the structure of the soil. In other cases, such as in the brushlands of southern California, water repellency is usually a disadvantage. Water-repellent substances that occur naturally in some brush species and in the litter layer vaporize during wildfires, filter down through the soil, and condense on soil particles, forming an impermeable layer. Rain falling on these recently burned areas can get through the wettable soil near the surface, but can't penetrate the water-repellent layer. With the normal infiltration process blocked, the upper soil layers become saturated. On steep slopes, the saturated layers may slip.

For the brushlands, DeBano recommends prescribed burning, when soils are moist. Prescribed burns will reduce the accumulation of hazardous natural fuels. But, because they are cooler and lighter than wildfires, the control burns won't contribute to the formation of water-repellent layers. In other areas, application of chemicals that can break down the water-repellent substances may be the answer. Additional information is in the Report, which may be requested from the Pacific Southwest Station.

Classification system prepared

A guide for classifying the wildland vegetation of southern California—from the Central Valley to the Mexican border—has been issued by the Pacific Southwest Station. The guide, *A Vegetation Classification System Applied to Southern California,* General Technical Report PSW-41, is the result of the combined efforts of two foresters, two wildlife biologists, and a botanist.

Senior author Timothy E. Paysen, a research forester with the Pacific Southwest Station, says the purpose of the vegetation classification system is "to enable resource managers, planners, and other specialists to define and name units of vegetation, regardless of the successional state of the ecosystem." He sees the system as "a basic language that can be used in discussing organizations of plants, or plant assemblages." It is suitable for both local and regional natural resource management activities, such as mapping and land-use planning.

In the new classification system for southern California vegetation, the black oak series is part of the broadleaf forest subformation.

In the system, vegetation ranging from cacti to conifers is arranged into a hierarchy of five levels—the formation, subformation, series, association, and phase. For example, areas dominated by deciduous or evergreen trees that are at least 15 feet tall and form a canopy cover of 60 percent or more are classified as the closed forest formation. Within it are the conifer forest and the broadleaf forest subformations. Within each subformation are series, such as the Coulter pine, Monterey pine, or mixed-conifer series of the conifer forest subformation, or the madrone, bigleaf maple, or canyon live oak series of the broadleaf subformation. A set of nine climatic regimes can be used to further define these vegetation types. The canyon live oak series, for example, could occur in either the montane or interior valley climate.

It is up to the users of the system to define the associations in their own areas, using the guidelines that the authors present. Guidelines are also given for defining the phase (growth stage or condition) of a given association. For example, the authors suggest that vegetation in the dwarf shrub formation can be classified into any one of six phases, depending upon the percentage of cover the formation occupies.

The southern California classification scheme is compatible with several other systems and is quite flexible, in that it allows for categories of vegetation to be added or deleted as additional information becomes available.

Further information is in the Report, which is available from the Publications Distribution Section, Pacific Southwest Station.

Ethnic choices in outdoor recreation

The "melting pot" theory of assimilating Americans into one mass-society has largely given way to a pluralistic view. For leisure activities, the pluralistic perspective of society has far-reaching policy consequences.

"Decisionmakers are now turning away from broad prescriptions for outdoor recreation deemed 'good for everyone,' and focusing more on specific needs of different groups," say Sociologists Randel Washburne and Paul Wall.

Their recent study is summarized in an Intermountain Station publication, *Black-White Ethnic Differences in Outdoor Recreation.* Washburne and Wall analyzed a national sample on outdoor recreation participation.

Socioeconomic factors, long thought to be the reason for differences in recreation participation by Blacks and Whites, have only limited effect, say the authors. They conclude that two cultural factors govern recreation choices. First, outdoor recreation choices may be made to conform to activities traditionally valued by an ethnic group. Second, both the activity and the site where it takes place may serve to set off and contrast one ethnic group from others.

Campaigns to redress imbalances in White and Black use of National and State parks and forests would be dubiously appropriate or effective under pluralistic assumptions, say the authors.

"Different ethnic and cultural groups would be the best judges of their own recreational preferences," the authors conclude.

Contact the Intermountain Station for Research Paper INT-249-FR26.

Dead timber produces products

Western white pine trees containing more than 300 million board feet are killed annually by white pine blister rust and mountain pine beetles in the United States, but less than 10 percent of this mortality is salvaged. Information that can help increase utilization of this dead timber is provided in a comprehensive report from the Pacific Northwest Station.

The publication reports on the products recovered from western white pine trees killed by blister rust and bark beetles in the Clearwater National Forest in Idaho. One hundred ninety-four trees, 9 to 34 inches d.b.h. were selected for the study. Of these, 17 were live, undeteriorated trees, and 177 represented three classes of deterioration: dead with some needles; dead with no needles but 90 percent bark; dead with no needles and less than 90 percent bark. Each tree was measured in the forest and followed through processing at cooperating mills according to normal routines.

The report discusses conditions which determine whether dead timber can be used. These include its availability, the acceptability of products from it, the costs of producing them and expected return. But before these considerations can be addressed, it is necessary to know how much and what kind of products could be recovered from timber that has been dead for varying periods. The paper provides insight into the relationship between defects that develop over time following mortality, systems for scaling dead timber, and the products that can be recovered.

Order *Dead western white pine: characteristics, product recovery, and problems associated with utilization,* Research Paper PNW-270, by Thomas A. Snellgrove and James M. Cahill, from the Pacific Northwest Station.

Grassland improves—with a little help

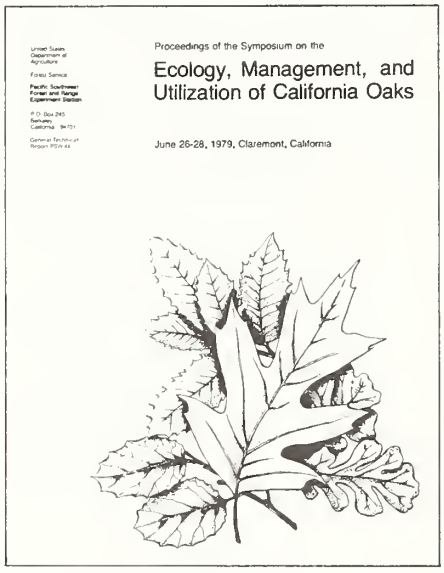
Reduction of sheep grazing resulted in a remarkable improvement in the condition of green fescue subalpine grassland in an area of northeastern Oregon between 1938 and 1978. Vegetation changes are discussed and illustrated by photos and vegetation surveys in a new publication from the Pacific Northwest Station.

In 1916, four 1,200-head bands of sheep grazed the allotment, including the study area in the Tenderfoot Basin near the headwaters of the North Fork of the Imnaha River. This stocking was 15 times greater than the area could support in 1938. By then the grassland, formerly prime summer range, was in very poor condition. After 50 years of heavy grazing, much topsoil had been lost to erosion, and the green fescue had been replaced by needlegrass, sedges, and forbs. Improvement began when sheep use was reduced or deferred to late summer after plant growth was completed. Improvement was greatest between 1968 and 1978, when green fescue again became the dominant grass on the range.

The story of improvement is described in *Green Fescue Grassland: 40 Years of Secondary Succession,* Research Paper PNW-274, by Elbert H. Reid, Gerald S. Strickler, and Wade B. Hall. Copies are available from the Pacific Northwest Station.

Oak woodlands summary issued

California's oak woodlands are the subject of a new, 368-page volume from the Pacific Southwest Station, *Proceedings of the Symposium on the Ecology, Management, and Utilization of California Oaks, June 26-28, 1979, Claremont, California,* General Technical Report PSW-44. Covered in the book are such topics as the evolution, hybridization, and distribution of oaks; techniques for production of seedlings and for thinning, harvesting, manufacturing, and marketing; and the value of oaks as a source of fuelwood, lumber, and scenic beauty. Other reports discuss problems posed by insects, disease, wildfire, flooding, air pollution, and urban expansion. Several papers describe the benefits—including food and shelter—that oaks provide for wildlife.



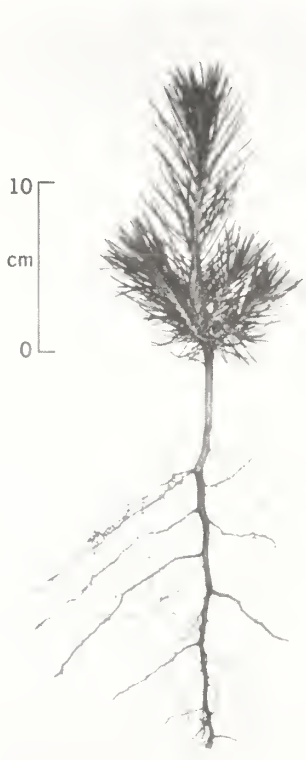
Timothy R. Plumb of the Pacific Southwest Station, who is technical coordinator of the Symposium Proceedings and was chairman of the Oak Management Symposium, explains that there are 17 different species of oaks that occur on some 15 million acres of oak woodlands in California. According to Plumb, these woodlands have "long been one of the most misused ecosystems in California." He explains, "During the last 200 years, probably more effort has been spent to remove and kill oaks than to grow and manage them." However, this trend is gradually beginning to change: Plumb says that more and more people are realizing the many values of the native oak species and the potential of oak woodlands in meeting energy and wildlife needs and in providing attractive lands for recreation. One indication of this interest was the attendance of more than 200 foresters and others at the Oak Symposium.

Copies of the Proceedings are available from the Publications Distribution Section, Pacific Southwest Station.

Plantation success - timing is the key

The key to establishing a successful plantation is knowing the proper time to lift seedlings from the nursery bed, and the proper time to outplant them in the field. These are points that Research Plant Physiologist James L. Jenkinson stresses in his new publication, *Improving Plantation Establishment by Optimizing Growth Capacity and Planting Time of Western Yellow Pines,* Research Paper PSW-154. The Report summarizes findings of a 4-year study, in which Jenkinson analyzed the growth capacity and field survival of bare-root seedlings of ponderosa pine, Jeffrey pine, and Washoe pine from 27 different sources in California and several other Western States. The purpose of the study was to determine the influence of seed source and date of lifting on seedling growth capacity. A second objective was to evaluate the effect of date of planting, and planting site environment on seedling survival in the field.

In the nursery work, Jenkinson evaluated root growth capacity—the ability of seedlings to develop new roots. He was able to delineate distinct, innate patterns: for some seedlings, growth capacity peaks in the fall; for others, in mid-winter. Some seedlings remain at a peak level from fall through winter, and others peak in fall and again in winter. Jenkinson says that when root growth capacity is "moderate to high," seedlings should be lifted from the nursery beds and kept in cold storage at 33° Fahrenheit.



Top and root growth on this first-year seedling are typical of ponderosa pine seed sources from the western Sierra Nevada.

The field experiments showed that seedlings can be safely planted on cleared sites early in spring, "when soils are warming sufficiently to enable water uptake and root enlongation." Soils that are warming above 40° to 45° F. are probably safe to plant.

The report includes further details about top and root growth capacity, planting site environments, and field survival. This information is primarily applicable to the California forest nursery and field conditions that were evaluated in the study. However, foresters in Oregon, Arizona, Wyoming, and Nevada may be interested in the growth capacity and field survival data on pines from those States. And, the report as a whole is a carefully prepared and useful reference for anyone interested in learning more about physiological patterns and requirements of yellow pine planting stock.

Effects of fire on western vegetation

Fire is the subject of four reports on widely diverse ecosystems—ponderosa pine forests, the sagebrush-grass and pinyon-juniper plant communities, the semidesert grass-shrub type, and the Great Plains. The comprehensive publications discuss the best use of fire to achieve management objectives in these major vegetation types of the western United States.

The reports are a result of cooperative efforts between Texas Tech University, Lubbock; and the Intermountain Station's Fire Effects Research and Development Program.

One report, *The Effect of Fire on Vegetation in Ponderosa Pine Forests* (Texas Tech's College of Agricultural Sciences Publication No. T-9-199), contains sections on management implications and state-of-the-art knowledge on the use of fire to manage these communities. The author is Henry A. Wright.

☆U.S. GOVERNMENT PRINTING OFFICE: 1981—779-957/337

Guidelines for conducting prescribed burns are given in *The Role and Use of Fire in Sagebrush-Grass and Pinyon-Juniper Plant Communities,* General Technical Report INT-58. The guidelines are based on an extensive survey of the literature and on practical field applications. Publication authors are Henry Wright, Leon F. Neuenschwander, and Carlton M. Britton.

General guidelines are recommended in *The Role and Use of Fire in the Semidesert Grass-Shrub Type,* General Technical Report INT-85. Report author Henry Wright also discusses research needs.

Fire Ecology and Prescribed Burning in the Great Plains, General Technical Report INT-77, contains basic ecological information, vegetative descriptions, and fire effects data for the shortgrass, mixed grass, and tallgrass prairies in the southern, central, and northern Great Plains. Authors are Henry Wright and Arthur W. Bailey.

Proceedings out on Fire History Workshop

The importance of fire in plant sucession is determined by its frequency, extent, and intensity. If land managers had such information on historical fires in their area, it would help them understand and manage plant communities.

The first Fire History Workshop was held in Tucson, Arizona in October, 1980. It facilitated the exchange of information on techniques and methods for determining fire histories based on tree-ring evidence. In addition, the Workshop provided a forum for reporting on fire history studies; the inspection, dating and interpretation of fire-scarred material; and resolving problems of terminology.

Scientists from the Laboratory of Tree-Ring Research, at the University of Arizona, provided expertise in the science of dendrochronology. When using dendrochronology to identify and describe historical fires, scientists recommend closely adhering to established guidelines for analyzing the material and interpreting the results.

For more information on fire history, contact the Rocky Mountain Station and request *Proceedings of the Fire History Workshop,* General Technical Report RM-81, edited by Marvin A. Stokes and John H. Dieterich.

Mountain developments vs. water quality

Mountain home developments are rapidly increasing in the western United States. The developments vary in design, and many of them are located near streams and lakes.

While the effects of forestry and livestock practices on water quality are reasonably well understood, the impacts of mountain home developments on water quality are not well understood.

During a two year study, scientists at the Rocky Mountain Station found that water quality problems stem primarily from homesite developments, road systems and improper sewage disposal. According to the scientists, recreation has little, if any, adverse impact on water quality.

Scientists believe that small community wastewater treatment plants and better home sewage treatment systems can help alleviate water pollution. Septic systems near streams should be phased out, because of minimal biological decontamination. Aerobic systems, along with chemical toilets and sealed storage vaults, should be considered as alternatives.

If you would like to know more about the impact of mountain home developments on water quality, contact the Rocky Mountain Station and request *Effects of Mountain Home Developments on Surface Water Quality: A Case Study.*Research Note RM-396, by Howard L. Gary, Stanley L. Ponce and Jim D. Dedrick.

You'll enjoy the next issue of Forestry Research West. In addition to the usual publication reviews, we'll look at the ecological characteristics of old growth forests; the Desert Experimental Range in the Great Basin; and read how scientists are testing the effectiveness of insecticides; plus more.

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